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Fe L-shell Diagnostics in Theory and Practice

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X-ray Diagnostics for Astrophysical Plasmas: Theory,
Experiment, and Observation
Cambridge, MA, United States
November 15, 2004 through November 17, 2004

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Fe L-shell Diagnostics in Theory and Practice

Christopher Mauche

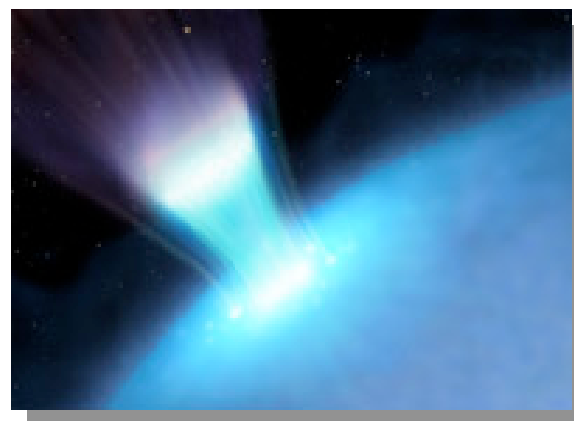
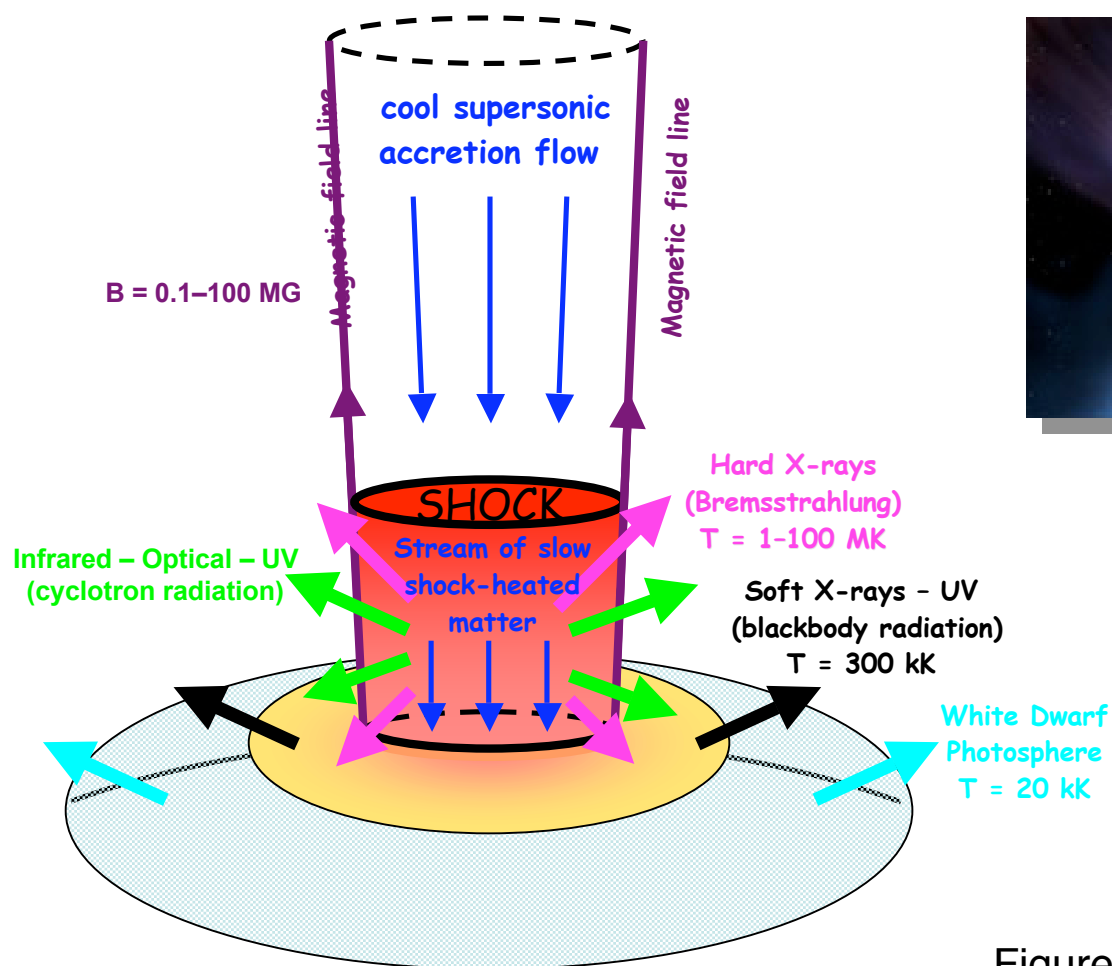
Duane Liedahl

Kevin Fournier

Lawrence Livermore National Laboratory

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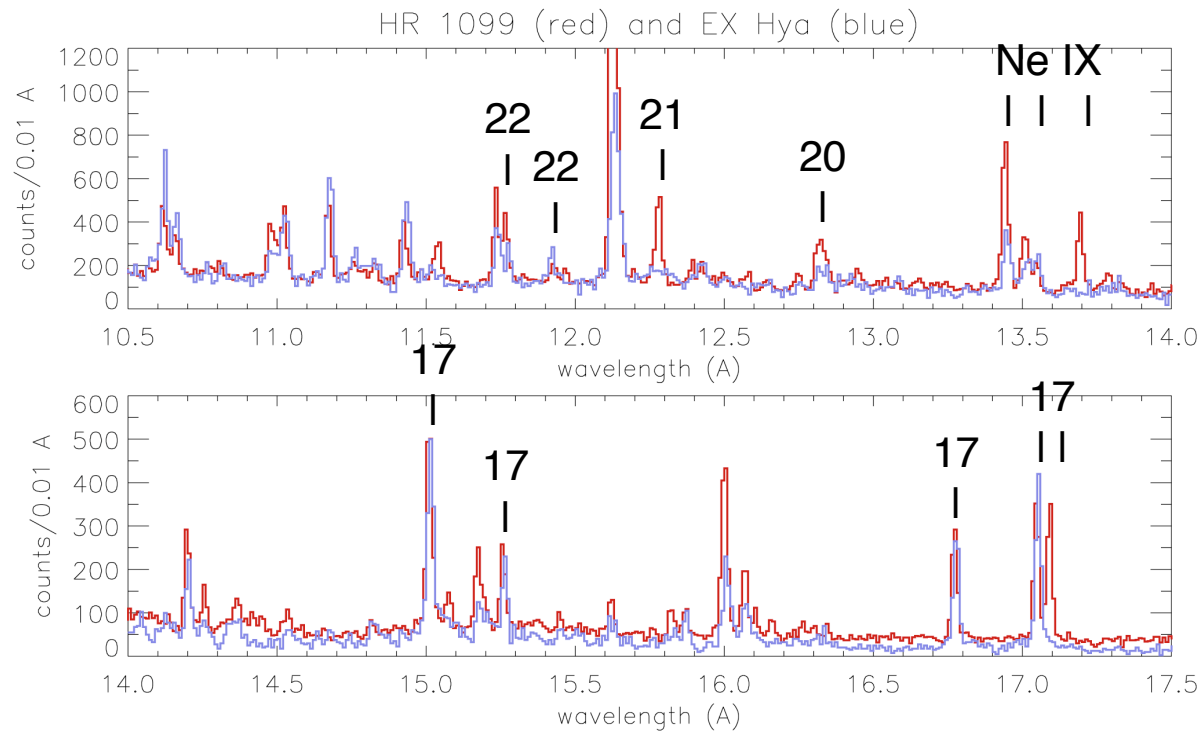
Accretion Geometry of Magnetic Cataclysmic Variables



- Density enhanced by:
- Magnetic channeling
 - Shock compression
 - Settling of the plasma

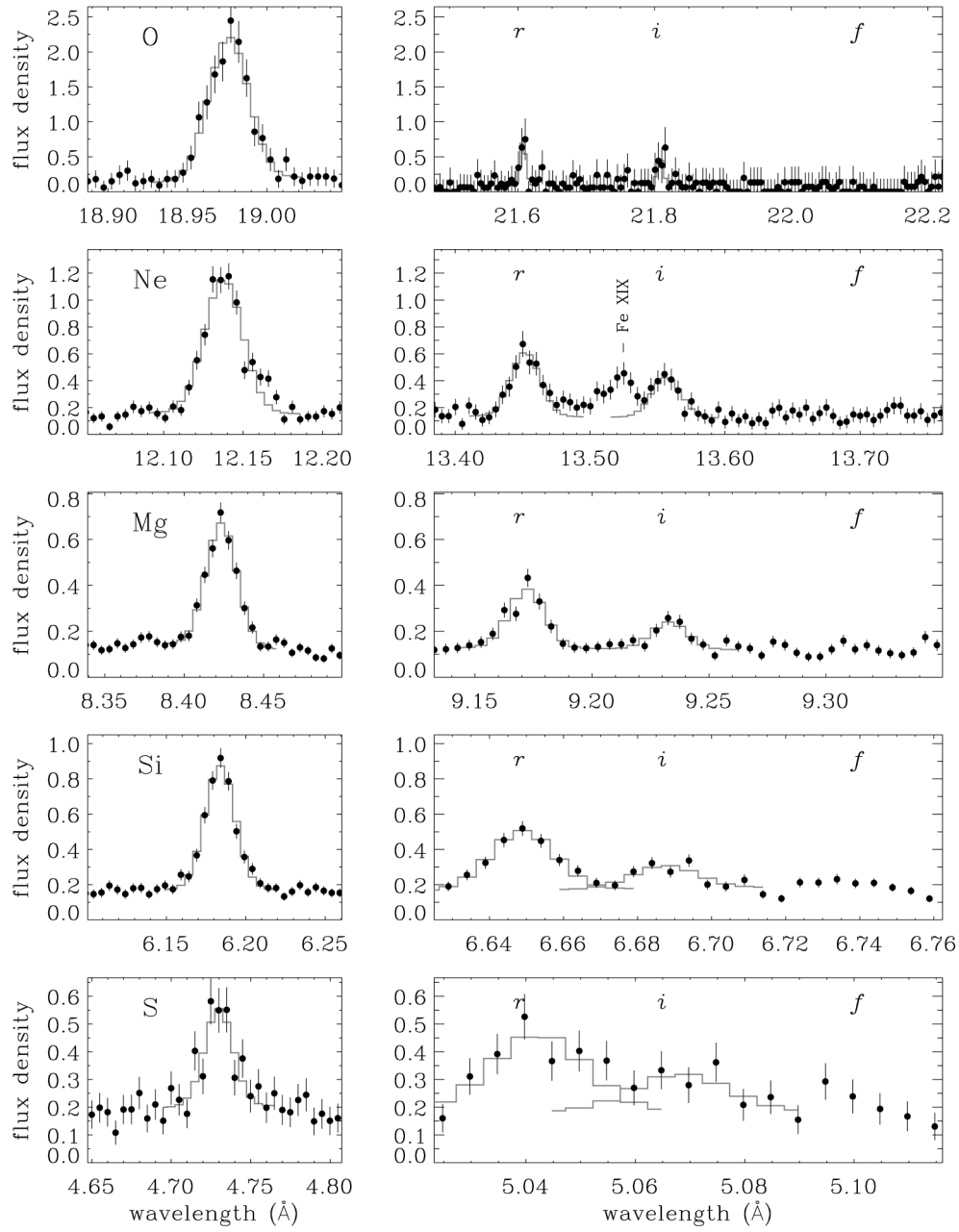
Figure courtesy of Vadim Burwitz

Comparison of HR 1099 and EX Hya



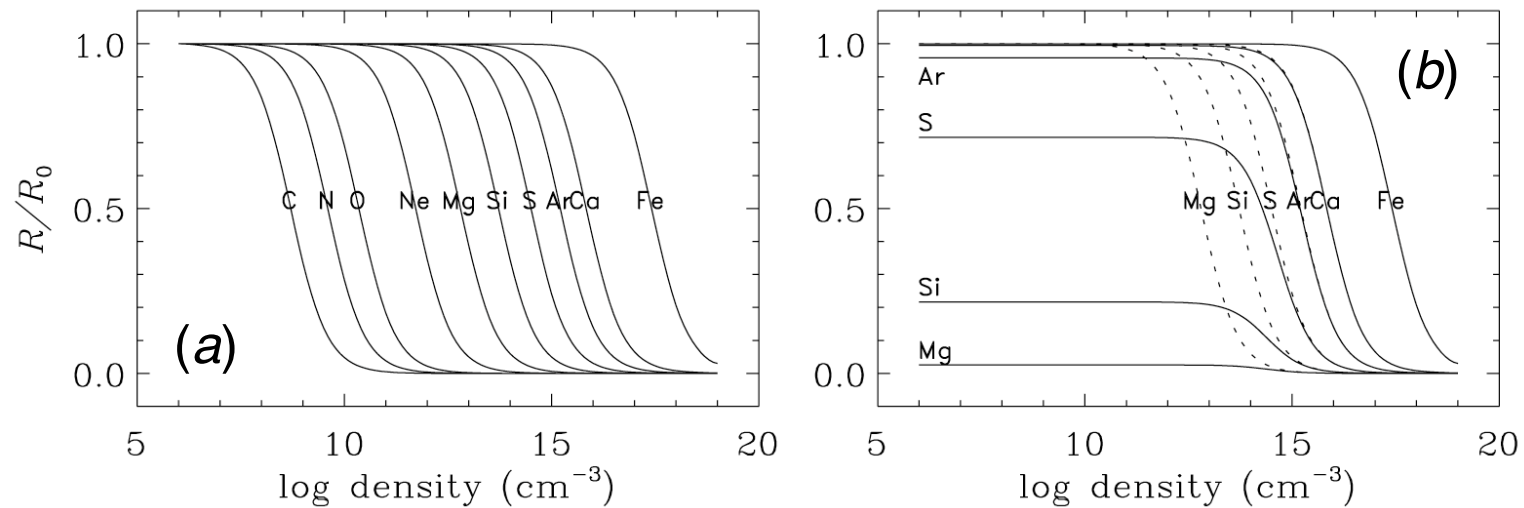
EX Hya is missing lines of: Fe XVII λ 17.10, Fe XX, Fe XXI, & has an inverted Fe XXII λ 11.92/ λ 11.77 ratio.

H- and He-like lines of EX Hya



All the He-like *f* lines are missing in EX Hya.

He-like $R = z/(x+y) = f/i$ line ratios as a function of density for (a) $T_{bb}=0$ and (b) $T_{bb}=30$ kK



Apparent absence of He-like f lines in EX Hya could be due to photoexcitation.

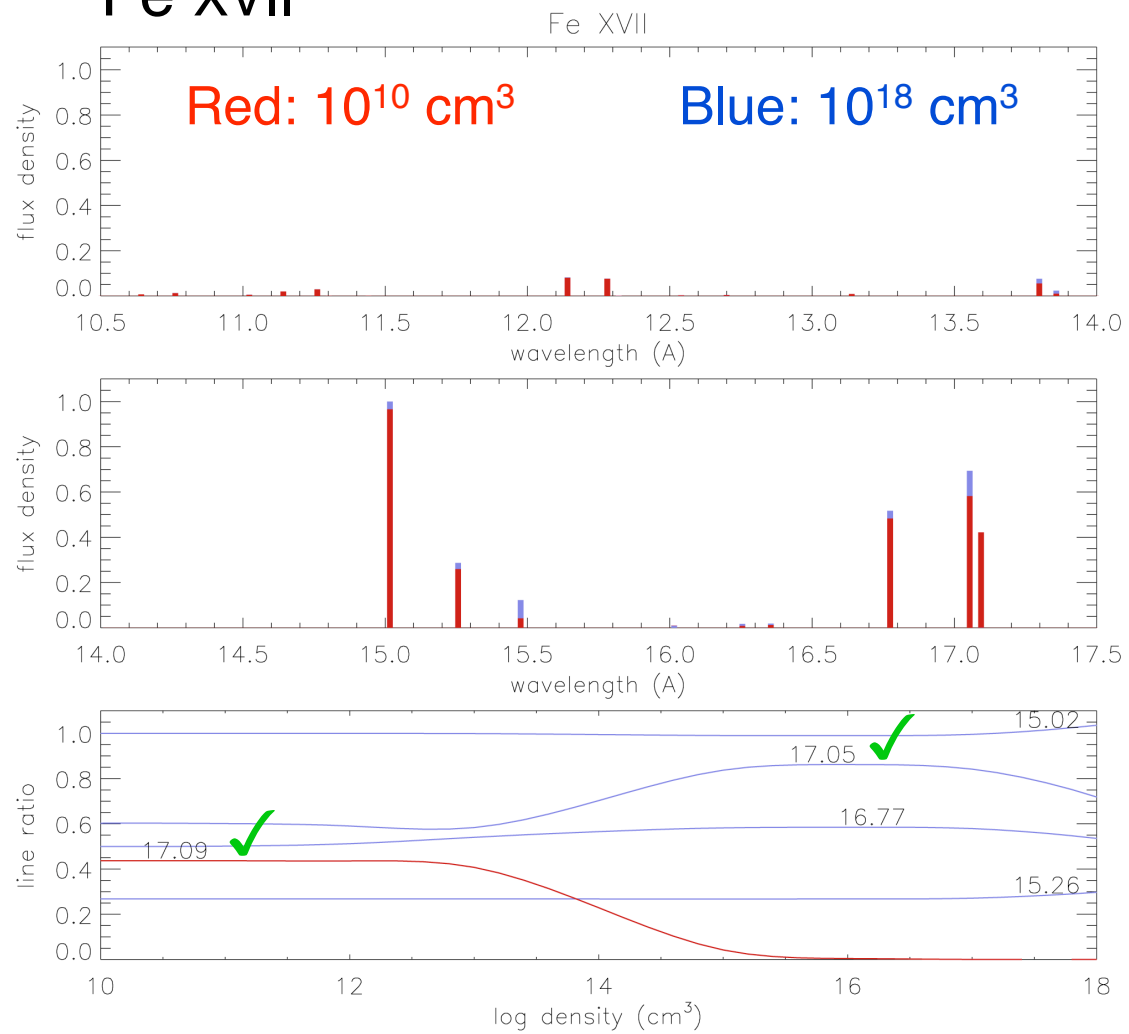
Mauche (2002, in Physics of CVs and Related Objects)

Fe L-shell spectra were calculated with the Livermore X-ray Spectral Synthesizer (LXSS), a suite of IDL codes that calculates spectral models as a function of temperature and density using HULLAC atomic data.

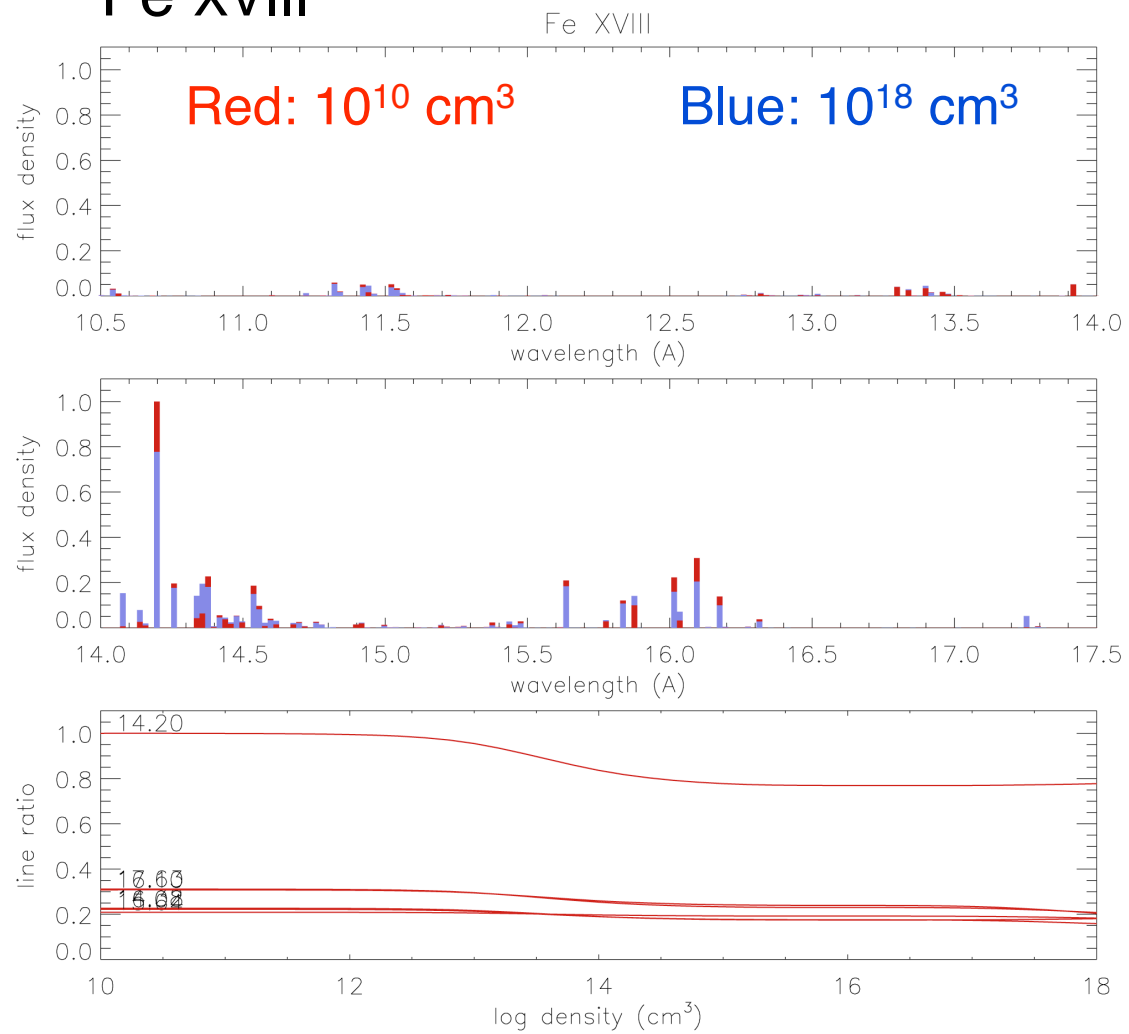
The following spectra are based on models with:

Ion	levels	radrate	colrate
Fe XXIV	76	4,100	1,704
Fe XXIII	116	8,798	6,478
Fe XXII	228	37,300	24,084
Fe XXI	591	227,743	153,953
Fe XX	609	257,765	165,350
Fe XIX	605	240,948	164,496
Fe XVIII	456	141,229	93,583
Fe XVII	281	49,882	33,887

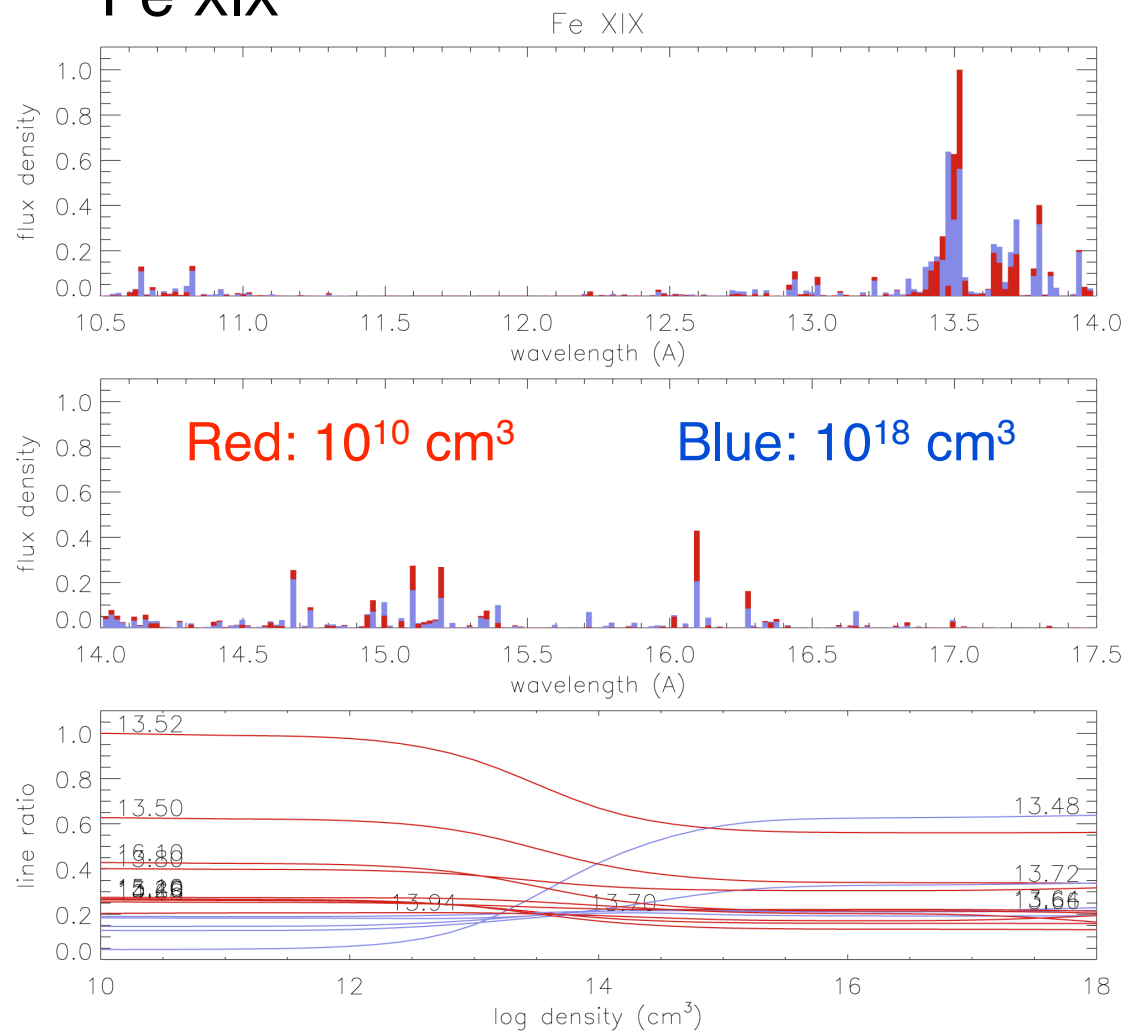
Fe XVII



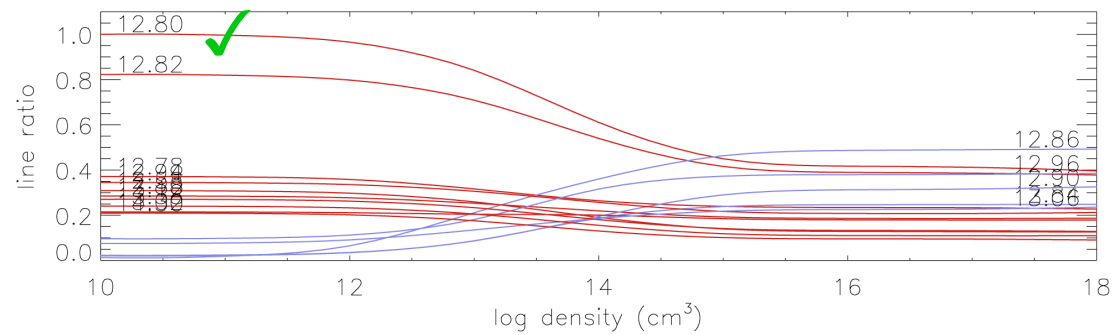
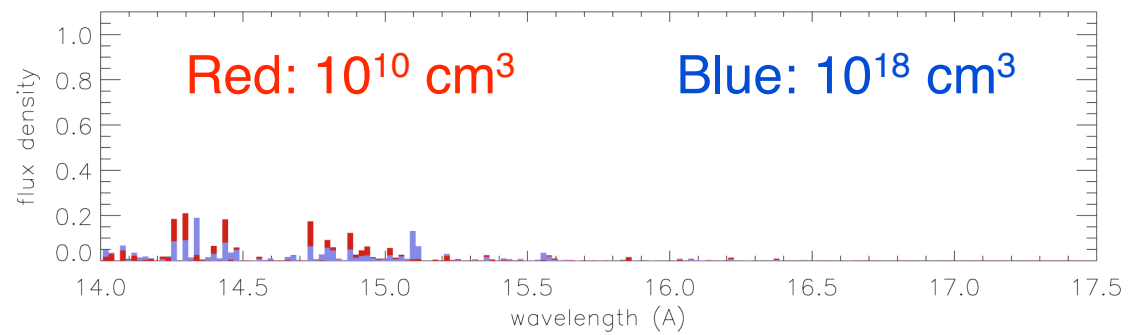
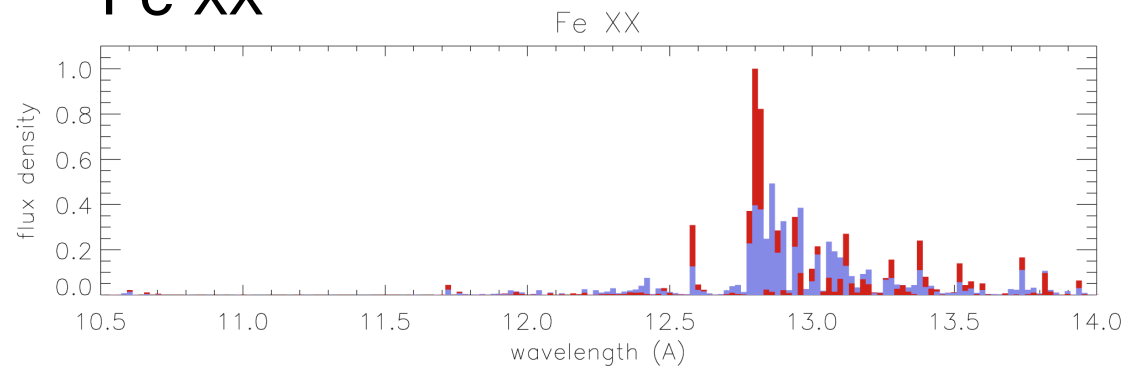
Fe XVIII



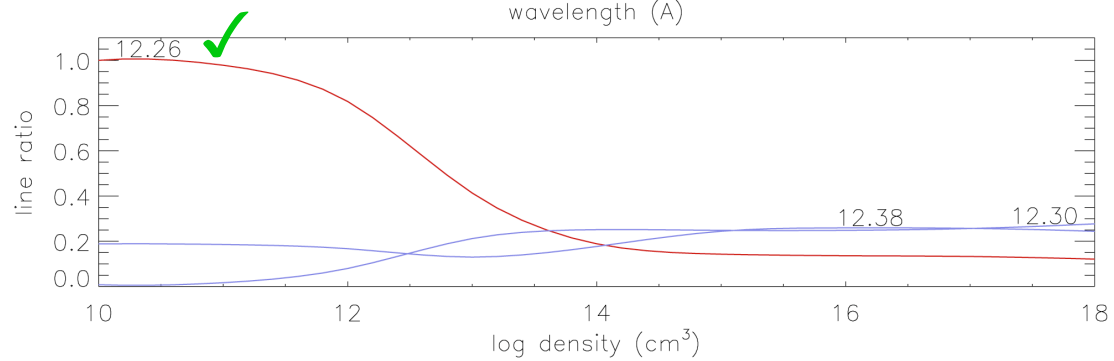
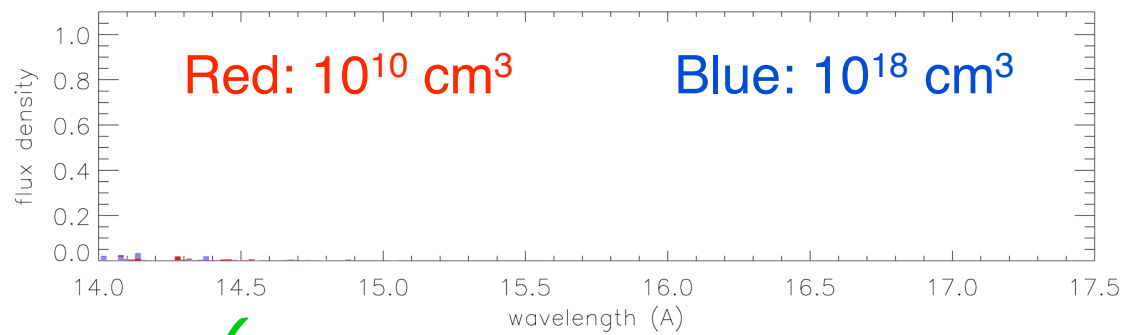
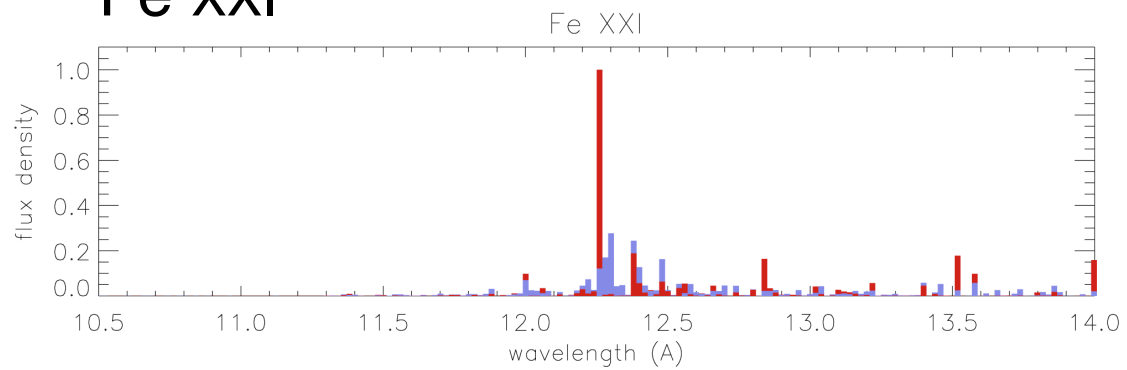
Fe XIX



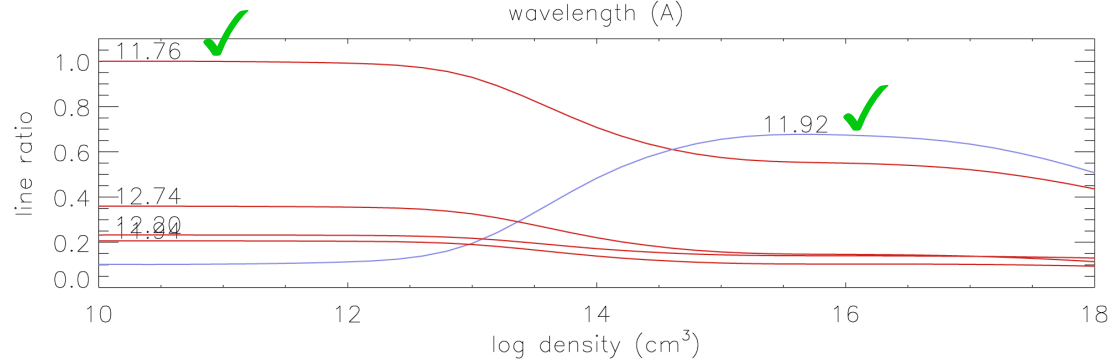
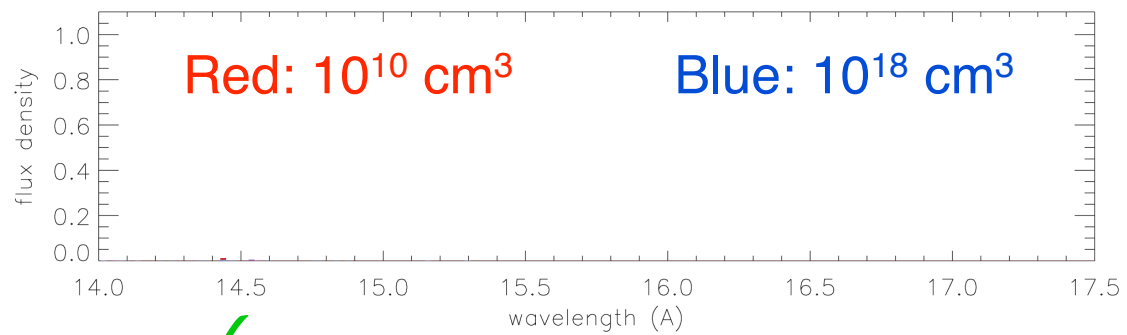
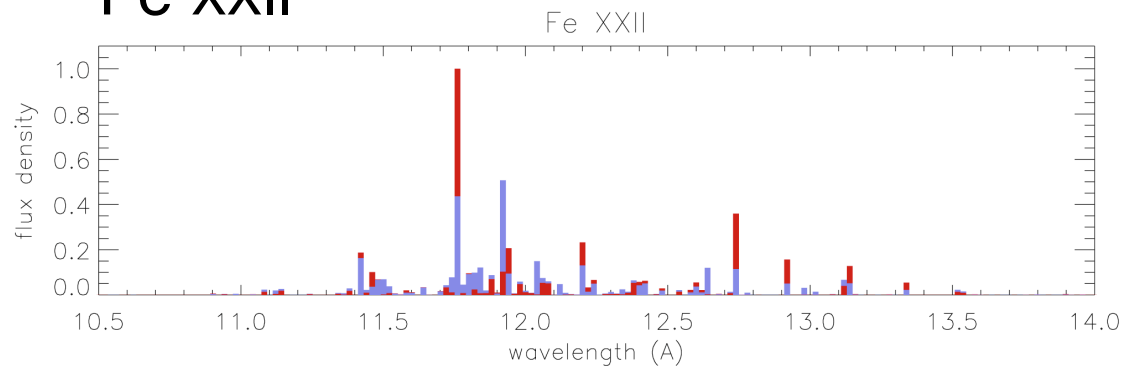
Fe XX



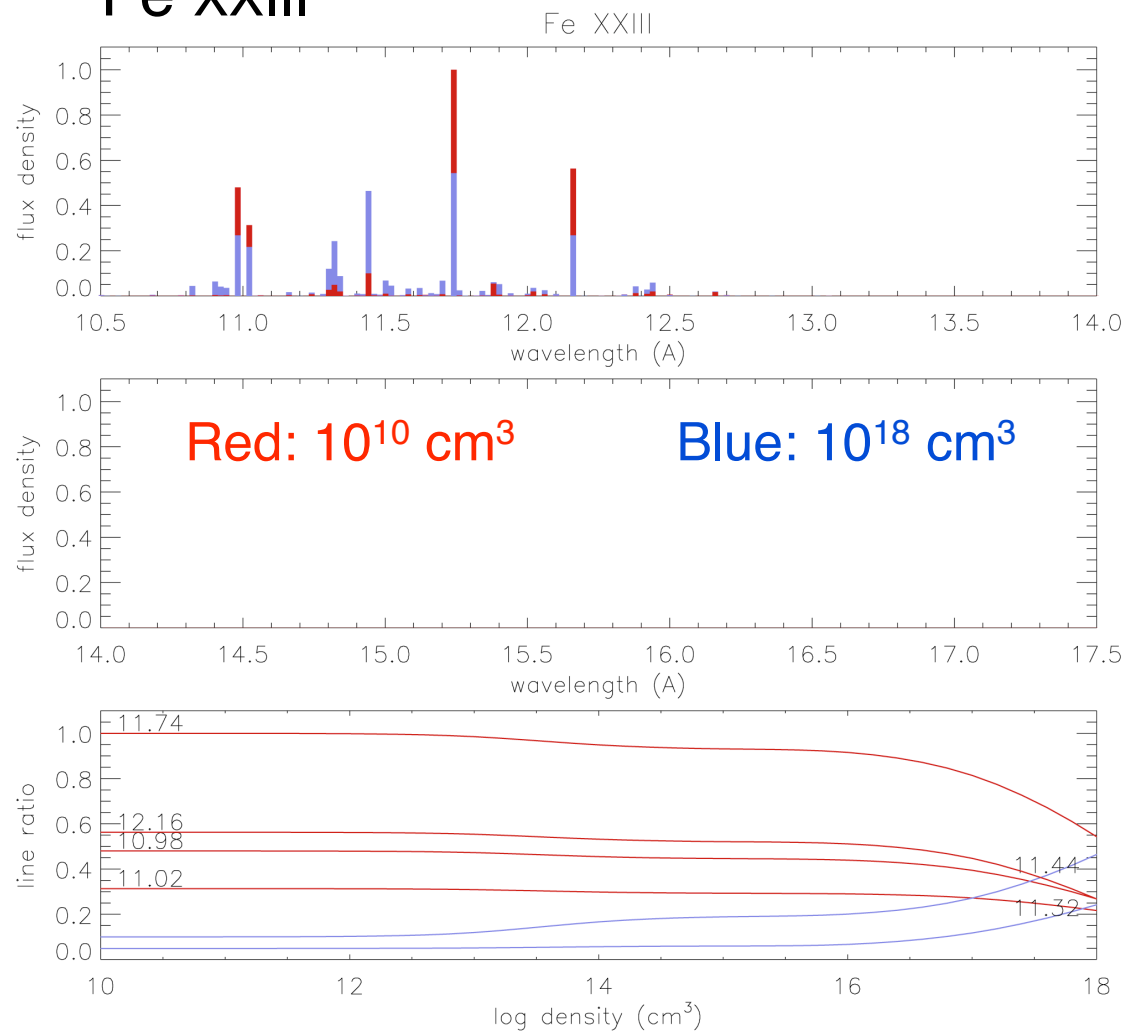
Fe XXI



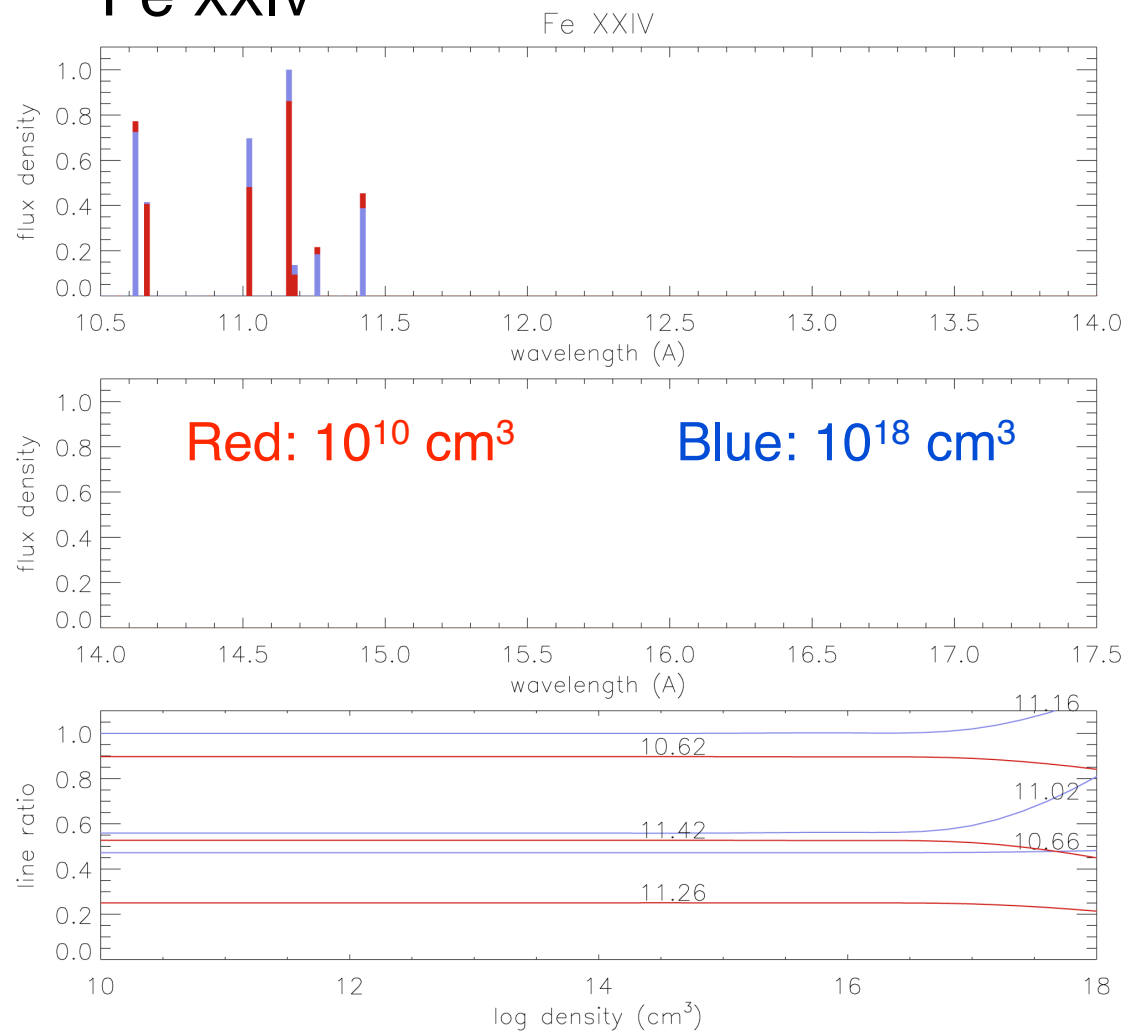
Fe XXII



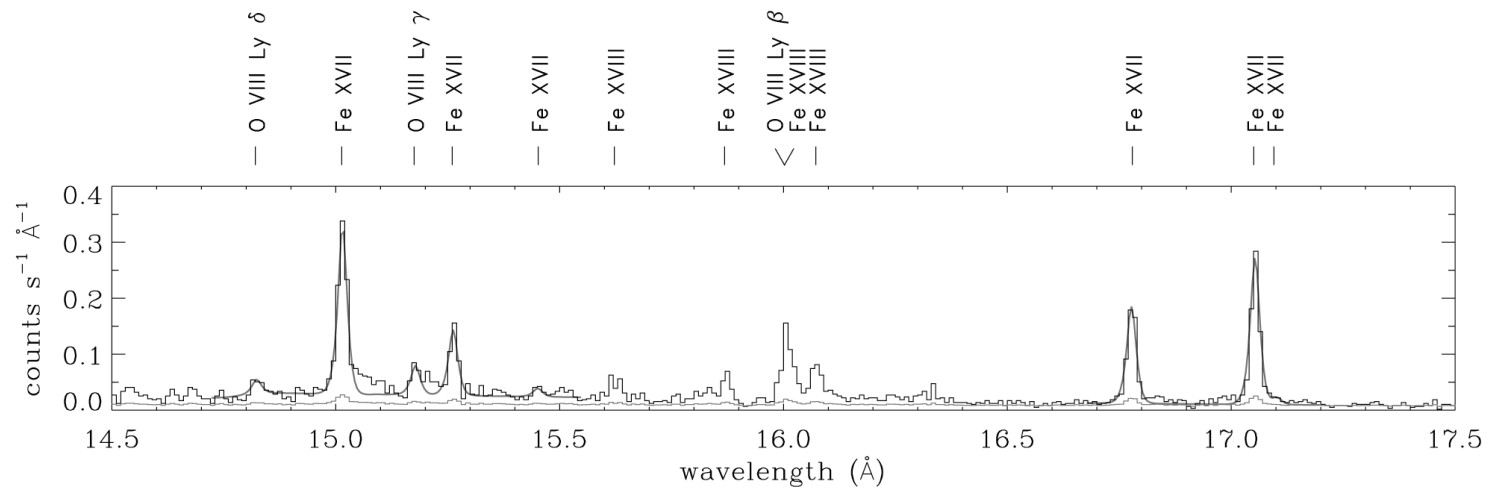
Fe XXIII



Fe XXIV

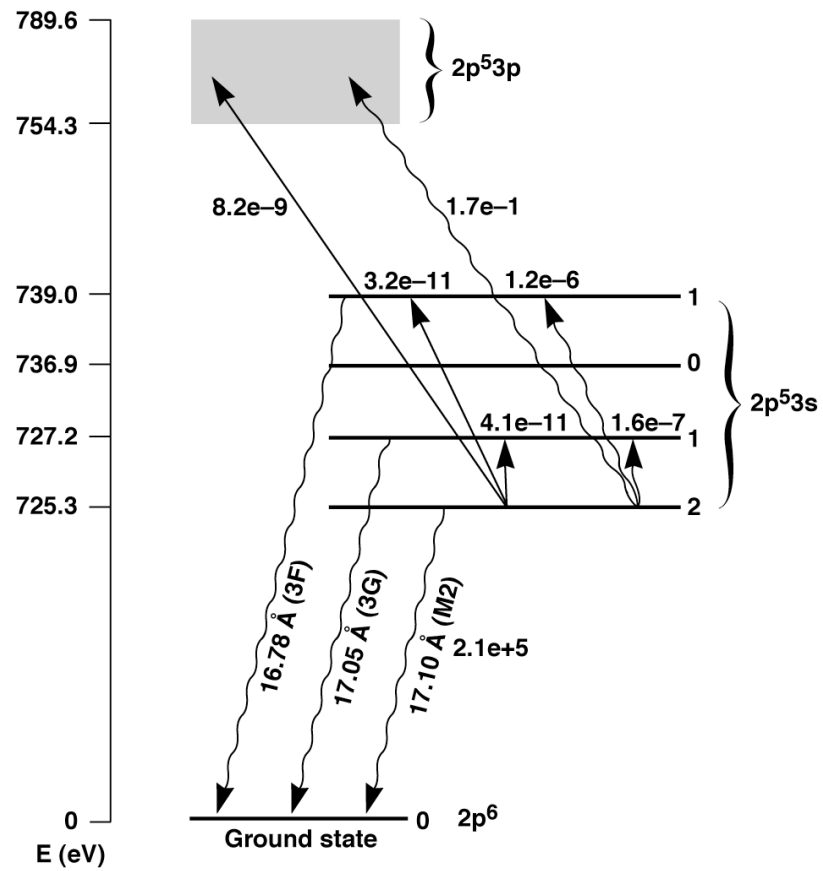


Fe XVII spectrum of EX Hya

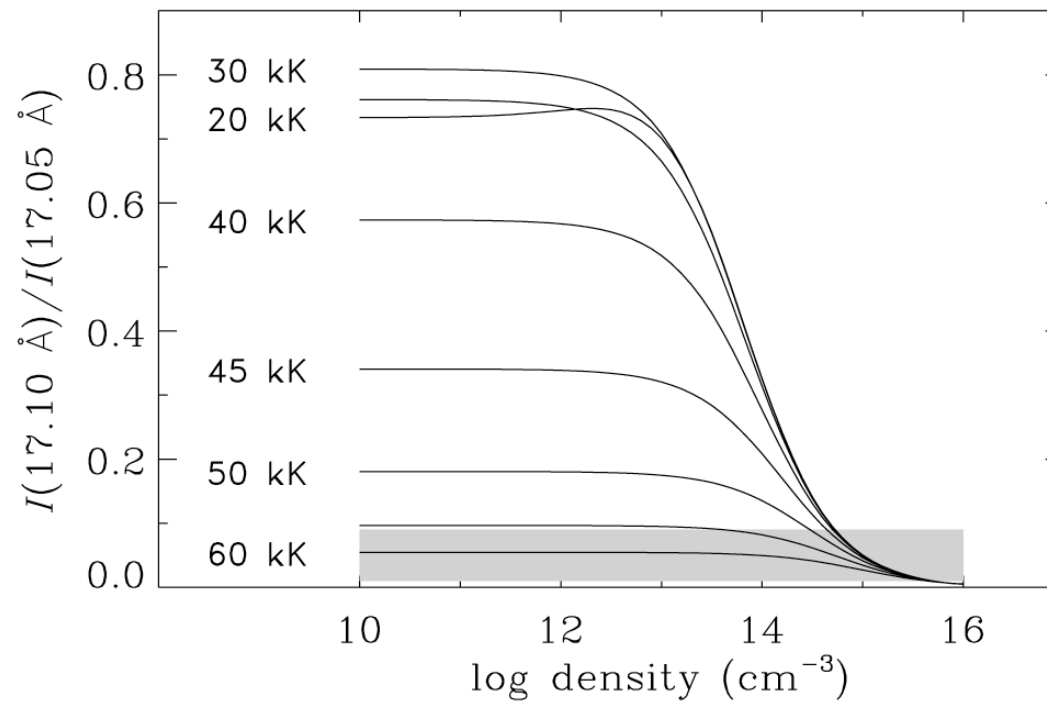


Mauche, Liedahl, & Fournier (2001, ApJ, 560, 992)

Level population processes in Fe XVII

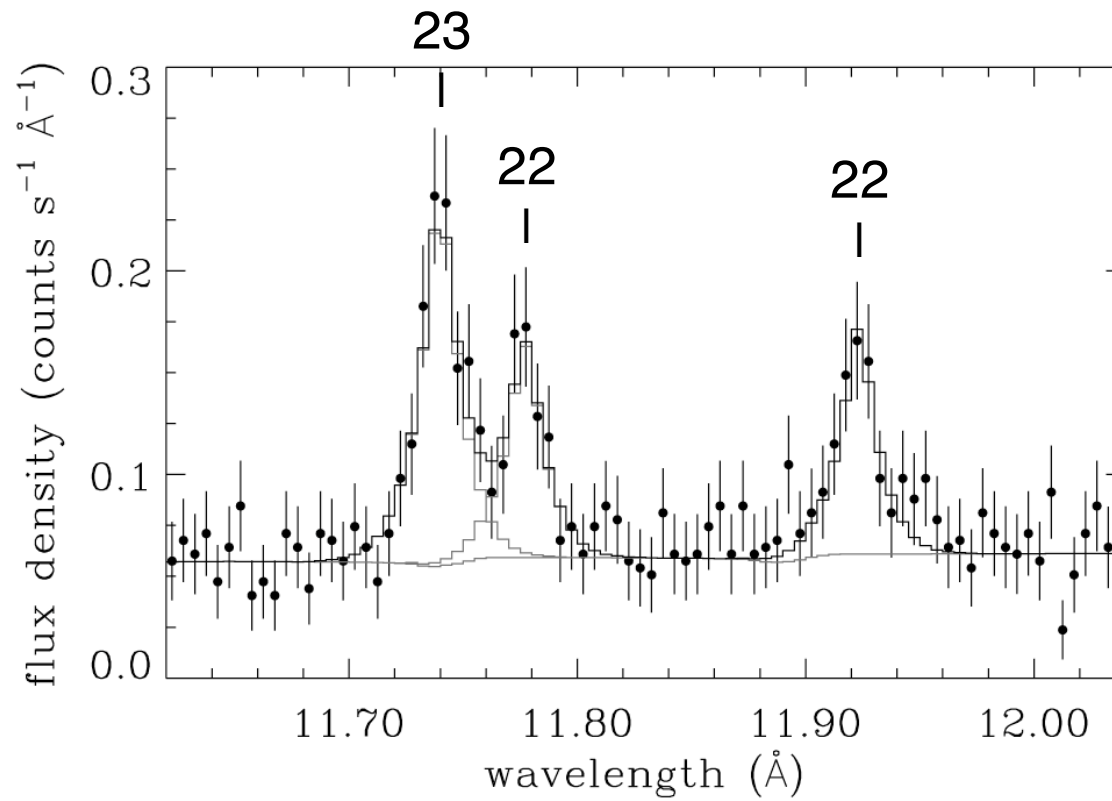


Fe xvii $\lambda 17.10/\lambda 17.05$ line ratio as a function of density for $T_e=4$ MK and $T_{bb}=20\cdots 60$ kK



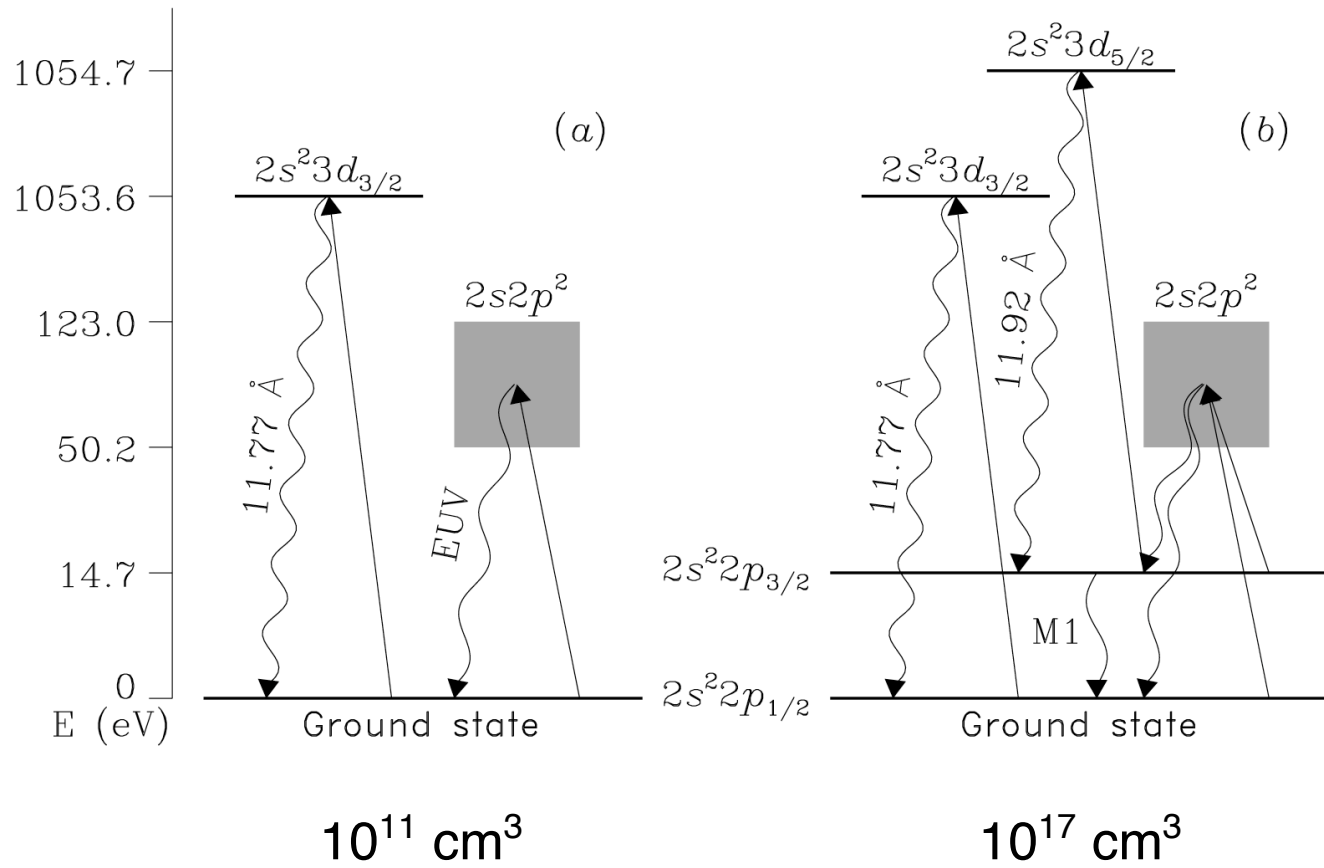
$n_e > 3E14 \text{ cm}^3$ or $T_{bb} > 55 \text{ kK}$

Fe XXII spectrum of EX Hya



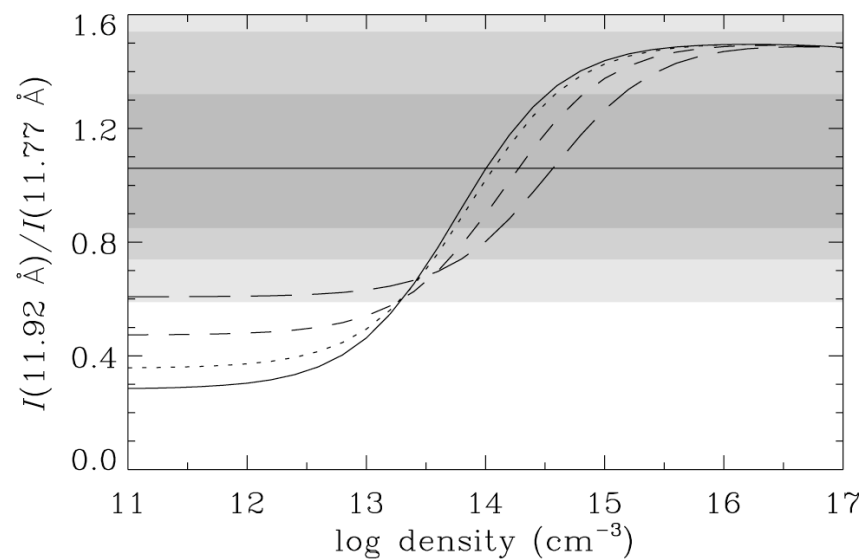
Mauche, Liedahl, & Fournier (2003, ApJ, 588, L101)

Dominant collisional and radiative channels of Fe XXII



Fe XXII $\lambda 11.92/\lambda 11.77$ line ratio as a function of density
for $T_e=12.8$ MK and $T_{bb}=0, 60, 80,$ and 100 kK

This calculation includes the relativistic R -matrix electron excitation rate coefficients of Zhang & Pradhan (1997) and the proton excitation rate coefficients of Foster, Keenan, & Reid (1997).



$n_e \sim 0.3\text{--}3\text{E}14 \text{ cm}^3$ (1σ) or $T_{bb} > 100 \text{ kK}$ (3σ)

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